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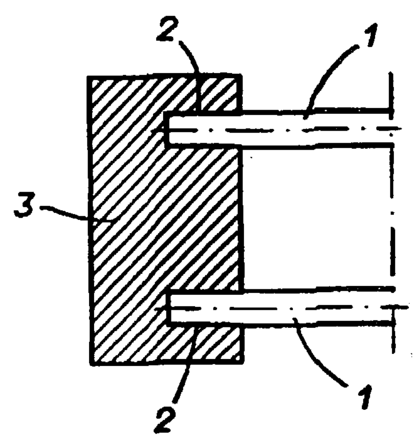
(54) Title: METHOD FOR CONNECTING TO EACH OTHER THE LINKS OF A METAL WRIST-WATCH BRACELET

(57) Abstract

Method for connecting to each other the links of a metal wrist-watch bracelet, according to which metal pins (1) forming the pivots are clamped with their ends in holes (2) in the links, which are either or not blind, characterized in that pins (1) are used made of a shape memory alloy with great hysteresis which is programmed such that, in a temperature range in which it has a martensitic structure, its thickness is smaller than the width of the hole (2), when it is heated up above said martensitic temperature range, it is transformed into an austenitic structure, a pin (1) is put in the hole (2) in the first-mentioned martensitic temperature range, the pin (1) is subsequently heated up above said martensitic temperature range, such that the width of the pin is increased until it touches the walls of the hole (2), and a clamping stress is then built up, and the pin (1) is finally cooled off until the service temperature of the pin (1) is reached.



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Method for connecting to each other the links of a metal wrist-watch bracelet.

The invention concerns a method connecting to each other the links of metal a metal wrist-watch bracelet, according to which metal pins are clamped with their ends in holes in the links which are either or not blind.

In known methods, clamping is mechanically, whereby a great force is required to press the pins in the holes.

The invention aims a method for connecting to each other the links of a wrist-watch bracelet which is simple and environmentally sound and which makes it possible to fix the pins without exerting any considerable force.
This aim is reached according to the invention because:
- pins are used made of a shape memory alloy with great hysteresis which is programmed such that, in a temperature range in which it has a martensitic structure, its thickness is smaller than the width of the hole, when it is warmed up above said martensitic temperature range, it is transformed into an austenitic structure, which transformation is characterized by an austenitic starting and final temperature and an increase in thickness which, when said increase is unhampered, is bigger than the width of the hole, to a maximum thickness at a certain higher austenitic final temperature, and such that when it is cooled off again, it is again transformed from an austenitic into a martensitic structure,
- a pin is put in the hole in the first-mentioned martensitic temperature range,

- the pin is subsequently heated up above said martensitic temperature range, such that the width of the pin is increased until it touches the walls of the hole, and a clamping stress is then built up, and
- the pin is finally cooled off at service temperature.

Shape memory alloys are already known. Their action is based on a metal structure transformation, characterized in that a martensitic structure changes into an austenitic structure at a specific temperature when heated up, and reassumes the martensitic structure when the temperature drops again. It is possible to associate a specific shape or diameter of a pin made of such material with each of the metal structures. This implies that when there is an increase or decrease in temperature, the shape or diameter of the pin will change or, if this change is prevented, a force will be created.

When such a shape memory alloy is heated up, the transformation into an austenitic structure, and thus the deformation, starts at a temperature A_s. This transformation lasts until the above-mentioned higher temperature A_f is reached. When it is cooled off again, the re-assuming of the martensitic structure does not start at the latter temperature, but at a lower return temperature, called the martensitic starting temperature M_s, which phenomenon is called hysteresis. The return to the martensitic structure comes to an end at a still lower temperature M_f.

Examples of such alloys are: Cu-Zn, Cu-Zn-Al, Cu-Zn-Si, Cu-Au-Zn, Cu-Al, Cu-Al-Ni, Ni-Ti, Ni-Ti-Cu, Ni-Ti-Fe, Ni-Ti-Nb, Ni-Ti-Zr, Ni-Ti-Hf, Fe-Ni-Al, Fe-Ni-Al-Ti, Fe-Ni-Co-Ti, Fe-Mn-Si, Ag-Cd, Au-Cd, Cu-Sn, Cu-Au-Zn, Cu-Zn-Be,

Cu-Zr, Ni-Al, Fe-Mn-Si-Cr-Ni, single-crystal as well as polycrystal.

A shape memory alloy can be used whose thickness decreases when it is cooled off again, during the re-transformation from the austenitic into the martensitic structure, as of a return temperature, i.e. the martensitic starting temperature, which is lower than the service temperature of the pin.

Preferably, the pin and the hole are round, and the above-mentioned thickness of the pin and the width of the hole are diameters.

According to an embodiment of the invention, use is made of a pin made of a memory alloy with an austenitic starting temperature which is higher than 40°C and a martensitic starting temperature which is lower than -10°C.

Preferably, the above-mentioned austenitic starting temperature is situated between 60 and 80°C, and the martensitic starting temperature is lower than -40°C.

Practically, a pin is used made of a memory alloy with an austenitic final temperature which is higher than 80°C and which is situated for example between 90°C and 200°C.

Other particularities and advantages of the invention will become clear from the following description of a method for connecting to each other the links of a metal wrist-watch bracelet, according to the invention. This description is given as an example only and does not

restrict the invention in any way. The reference figures refer to the accompanying drawings, in which:

figure 1 represents a cross section of a part of a link of a wrist-watch bracelet with a pin clamped in a hole by means of the method according to the invention;

figure 2 shows a diagram with the taper of the diameter of the pin as a function of the temperature;

figure 3 shows a diagram analogous to that in figure 2, but in relation to another metal for the pin.

Figure 1 shows a part of a link of a wrist-watch bracelet in which two round metal pins 1 are clamped in round blind holes 2 in end parts 3.

A good clamping is realized if the force required to draw a pin 1 from the hole 2 is bigger than 175 Newton. This would normally also be the force required to press the pin in the hole. According to the invention, such a good clamping can be obtained without any force having to be exerted on the pin 1 to put it in the hole 2.

This is realized according to the invention by using a pin 1 which is made of a shape memory alloy which was specially programmed to this end.

A known shape memory alloy can be used such as an alloy from the following series: Cu-Zn, Cu-Zn-Al, Cu-Zn-Si, Cu-Au-Zn, Cu-Al, Cu-Al-Ni, Ni-Ti, Ni-Ti-Cu, Ni-Ti-Fe, Ni-Ti-Nb, Ni-Ti-Zr, Ni-Ti-Hf, Fe-Ni-Al, Fe-Ni-Al-Ti, Fe-Ni-Co-

Ti, Fe-Mn-Si, Ag-Cd, Au-Cd, Cu-Sn, Cu-Au-Zn, Cu-Zn-Be, Cu-Zr, Ni-Al, Fe-Mn-Si-Cr-Ni, single-crystal as well as polycrystal.

Loose pins, but advantageously a thread, for example a thread wound on a roll, which is cut into pieces of the required length so as to form pins, just before use, is programmed according to the usual techniques, i.e. subject to a thermo-mechanical treatment, so as to memorize another shape when the alloy is transformed from a martensitic structure at a lower temperature to an austenitic structure at a higher temperature. This deformation implies in the case of a pin or a thread a change in length and diameter, and in particular a shrinking in length of the thread and an increase in diameter when the thread is elongated in the martensitic structure. The change of length is taken into account when determining the required length of the pins 1, whereas the change of the diameter is used to clamp the pin 1 in a hole 2.

One has to make sure that the diameter of the pin 2 or of the thread of the programmed-memory alloy is somewhat smaller than the diameter of the hole 2 when it has a martensitic structure, but somewhat bigger than the diameter of the hole 2 when it has an austenitic structure. Further, one has to make sure that the temperature A_s at which the transformation into the austenitic structure starts, and which thus represents the end of the temperature range in which the alloy has the martensitic structure, is as high as possible and in any case higher than the maximum service temperature of the pin, which is for a wrist-watch strip the maximum ambient temperature. In practice, said A_s temperature is

selected in any case higher than 40°C and preferably between 60°C and 80°C, or even higher than 80°C. The complete austenitic structure is reached at the austenitic final temperature A_f which is preferably higher than 80°C, for example between 90°C and 200°C. When it is cooled off again, the re-assuming of the martensitic structure does not start at this final temperature A_f, but at a lower return temperature M_s, which should be as low as possible and should in any case be situated under the normal service temperature. This implies that the hysteresis of the alloy must be as large as possible. Preferably, the temperature M_s is situated significantly below 0°C, preferably under -10°C and even under -40°C. The return to the martensitic structure comes to an end at a still lower temperature M_f.

The pins 1 or the thread from which the pins 1 are cut are stored at a temperature which is lower than the austenitic starting temperature A_s. If thread is used, pins 1 are cut off. Each of the pins 1 which thus have a diameter which is somewhat smaller than the diameter of a hole 2 are put in this hole 2 without any force having to be exerted, after which the pin is heated up to a temperature which is higher than the austenitic starting temperature A_s. During the transition from the original martensitic structure into the austenitic structure, the diameter of the pin 1 increases, when the pin is heated up freely, until the diameter is bigger than that of the hole 2. The increase in diameter of the part of the pin 1 which is put in the hole 2 is limited by the end part 3, however, which results in a great tension on this end in the hole 2, such that this end is clamped very firmly in the hole 2. Said clamping is preserved for the entire temperature range between the warming-up temperature and

the final temperature M_f of the return to the martensitic structure, i.e. for all normal service temperatures to which the wrist-watch strip is exposed. Tensile forces of over 175 Newton are required to pull the pin 1 out of the hole 2 in this temperature range.

For alloys on a basis of Fe-Mn-Si, said clamping is preserved for the entire temperature range under the warming-up temperature.

Since, during the transformation from the martensitic into the austenitic structure, not only the diameter increases but also the length decreases, this should be taken into account when determining the length of the pins 1 before the application, and this length should be for example some 5% longer.

Naturally, the most critical temperature is the starting temperature A_s for the transformation into the austenitic structure, whereas also the return temperature M_s is important. These temperatures depend on the choice of the alloy and especially on the thermo-mechanical treatment and thus the programming of the alloy.

Figures 2 and 3 show two examples of the taper of the diameter of the pin as a function of the temperature of a pin 1 which is to be clamped in a hole of 1.40 mm. The pin was made of a thread made of a memory alloy with an original diameter of 1.72 mm which, after deformation and annealing, had a diameter of 1.44 mm. In its martensitic state, the thread was deformed until its diameter was 1.38 mm, 1.39 mm respectively, after which a pin was cut off from the thread.

The pin to which figure 2 relates is put in the hole 2 at an ambient temperature, and thus with a diameter of 1.38 mm, after which the pin is heated up to 52°C. As of 43°C, the structural transformation starts. The original deformation, which was 8.2%, decreases when the pin is heated up freely to 2.8%, and the diameter increases to 1.42 mm. In the hole 2, the deformation is restricted to 5.5%, which results in a high tension of 200 N. This tension was maintained in a temperature range between 52 and -85°C.

The latter A_s temperature of 43°C is still relatively low, and by means of a suited thermo-mechanical treatment, consisting of a larger deformation of the martensite, or through stabilization of this phase, said A_s temperature for the pin was increased to 80°C according to figure 3. However, said pin 1 needs to be warmed up to 160°C after it has been put in the hole 2. The diameter of the pin 1 increased from 1.39 mm to 1.43 mm when the expansion could take place freely. In the hole 2 was created a tension of 240 N in the pin 1, which was maintained between 160°C and -40°C.

According to the above-described manners, the application of the pins is very easy and simple, and an excellent clamping of the pins in the holes is obtained for a large temperature range. They only need to be heated up. When the pins are manufactured in an industrial manner, their cost price can be relatively low.

The invention is by no means limited to the above-described embodiments; on the contrary, many changes can be made to the described embodiments within the scope of the patent application, among others as far as shape and

dimensions of the parts are concerned which are used to realize the invention.

In particular, the pin and the hole do not necessarily need to be round.

Claims.

1. Method for connecting to each other the links of a metal wrist-watch bracelet, according to which metal pins (1) forming the pivots, are clamped with their ends in holes (2) in the links, which are either or not blind, characterized in that

- pins (1) are used made of a shape memory alloy with great hysteresis which is programmed such that, in a temperature range in which it has a martensitic structure, its thickness is smaller than the width of the hole (2), when it is heated up above said martensitic temperature range, it is transformed into an austenitic structure, which transformation is characterized by an austenitic starting and final temperature (A_s and A_f) and an increase in thickness which, when said increase is unhampered, is bigger than the width of the hole (2), to a maximum thickness at a certain higher austenitic final temperature (A_f), and such that when it is cooled off again, it is again transformed from an austenitic into a martensitic structure,
- a pin (1) is put in the hole (2) in the first-mentioned martensitic temperature range,
- the pin (1) is subsequently heated up above said martensitic temperature range, such that the width of the pin is increased until it touches the walls of the hole (2), and a clamping stress is then built up, and
- the pin (1) is finally cooled off until the service temperature of the pin (1) is reached.

2. Method according to the above claim, characterized in that as a shape memory alloy, one of the following alloys

can be used: Cu-Zn, Cu-Zn-Al, Cu-Zn-Si, Cu-Au-Zn, Cu-Al, Cu-Al-Ni, Ni-Ti, Ni-Ti-Cu, Ni-Ti-Fe, Ni-Ti-Nb, Ni-Ti-Zr, Ni-Ti-Hf, Fe-Ni-Al, Fe-Ni-Al-Ti, Fe-Ni-Co-Ti, Fe-Mn-Si, Ag-Cd, Au-Cd, Cu-Sn, Cu-Au-Zn, Cu-Zn-Be, Cu-Zr, Ni-Al, Fe-Mn-Si-Cr-Ni, single-crystal as well as polycrystal.

3. Method according to any of the above claims, characterized in that a shape memory alloy is used whose thickness decreases during the re-transformation from the austenitic into the martensitic structure, when it is cooled off again, as of a return temperature, i.e. the martensitic starting temperature (M_s), which is lower than the service temperature of the pin (1).

4. Method according to any of the above claims, characterized in that the pin (1) and the hole (2) are round, and that the above-mentioned thickness of the pin (1) and the width of the hole (2) are diameters.

5. Method according to any of the above claims, characterized in that use is made of a pin (1) made of a memory alloy with an austenitic starting temperature (A_s) which is higher than 40°C.

6. Method according to the above claim, characterized in that the austenitic starting temperature (A_s) is situated between 60 and 80°C.

7. Method according to any of the above claims, characterized in that use is made of a pin (1) made of a memory alloy with an austenitic final temperature (A_f) which is higher than 80°C.

8. Method according to the above claim, characterized in that use is made of a pin (1) made of a memory alloy with an austenitic final temperature (A_f) which is situated between 90°C and 200°C.

9. Method according to any of the above claims, characterized in that use is made of a pin (1) made of a memory alloy with a martensitic starting temperature (M_s) which is lower than -10°C.

10. Method according to any of the above claims, characterized in that use is made of a pin (1) made of a memory alloy with a martensitic starting temperature (M_s) which is lower than -40°C.

11. Method according to any of the above claims, characterized in that the pin (1) is applied as a pivot between links of a wrist-watch strip.

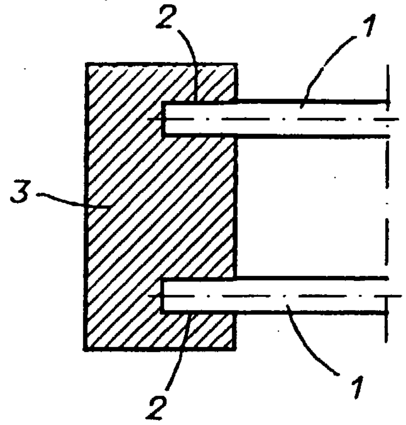

Fig.1

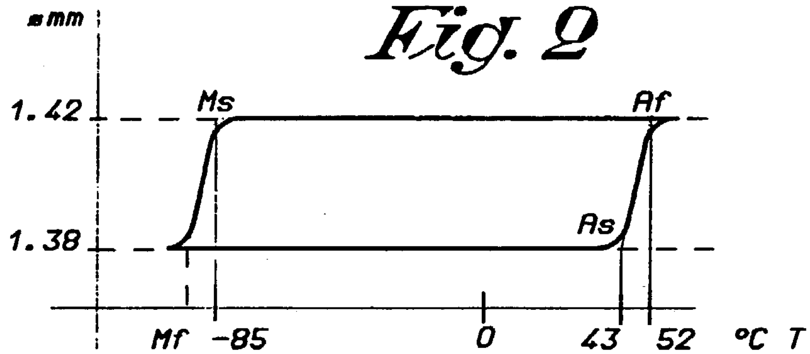

Fig. 2

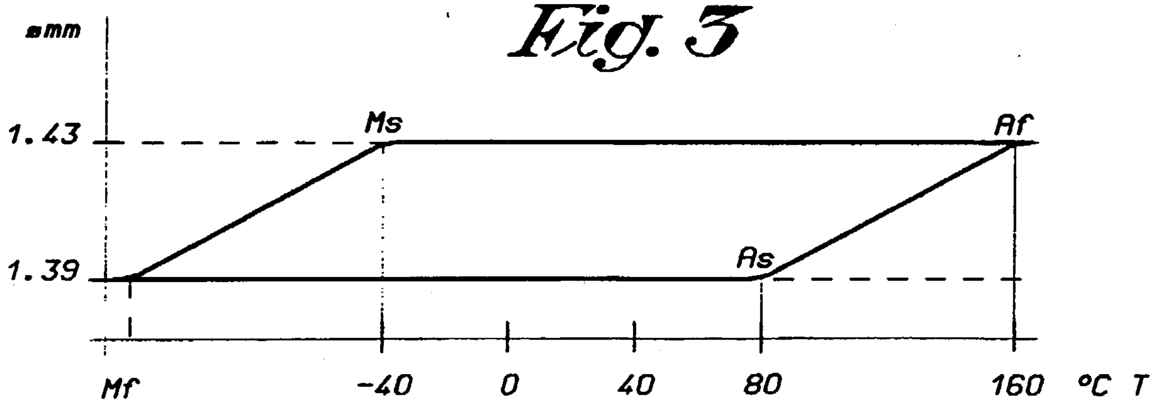

Fig. 3

INTERNATIONAL SEARCH REPORT

Inter. ...onal Application No
PCT/BE 94/00026

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 F16B4/00 A44C5/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 F16B A44C

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	see column 6, line 21 - line 33 see column 7, line 17 - line 45 see column 8, line 36 - column 9, line 13; figures 1-16 ---	11
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X	FR,A,2 306 782 (RAYCHEM CORPORATION) 5 November 1976 see claims 1,13,15-18,20; figures 1A,1B,16,17 --- -/--	1-5,9,10

[X] Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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